BLIP Raster System
Project Overview and Status

Rob Michnoff

2014 BLIP Isotope Program Biennial Science & Technology Review
November 13, 2014

Outline

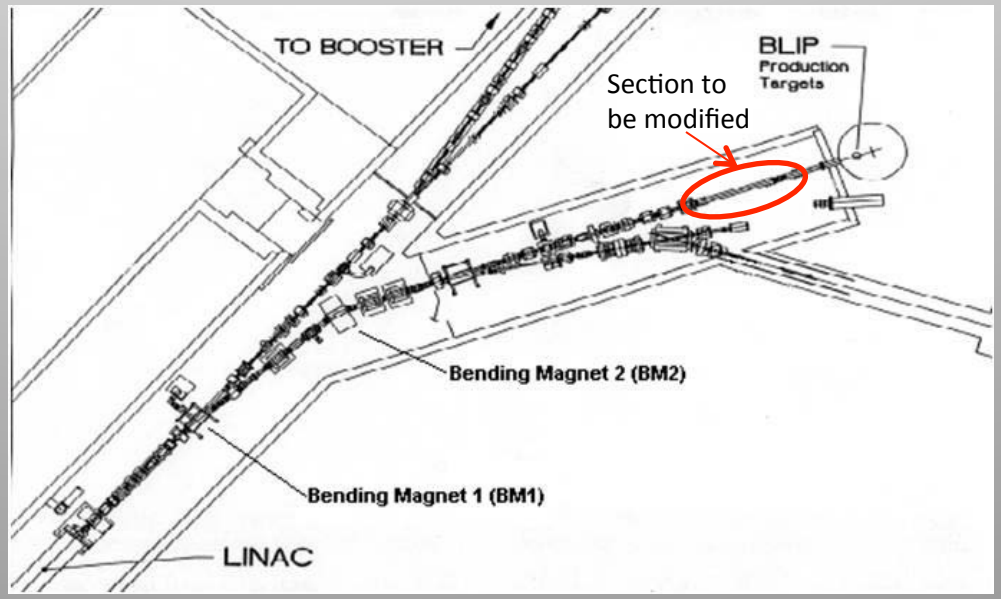
- Motivation and Project Initiation
- Project Mission and Purpose
- Project Scope
- Schedule, Financials, Milestones, Risks
- Hazards
- Status
- Photos
- Plan for raster magnet fabrication and testing
- Short-term to-do list
- Summary

Motivation and Project Initiation

- The design and installation of a beam raster system at the Brookhaven Linac Isotope Producer (BLIP) will increase isotope yield and sharply reduce target fatigue.
- It is estimated that the return on investment can be realized within 3 years after completion (5/2016 is the planned early finish date).
- After technical, cost, schedule and management review in Sept. 2013, the $4.5M baseline and schedule for the Raster Accelerator Improvement Project (AIP) was approved by the Office of Nuclear Physics (ONP) in Dec. 2013.
- Authorization to begin work related to long lead items was provided by ONP in November, 2013.

LINAC building and BLIP beam line

Existing BLIP Y Section inside Linac Tunnel

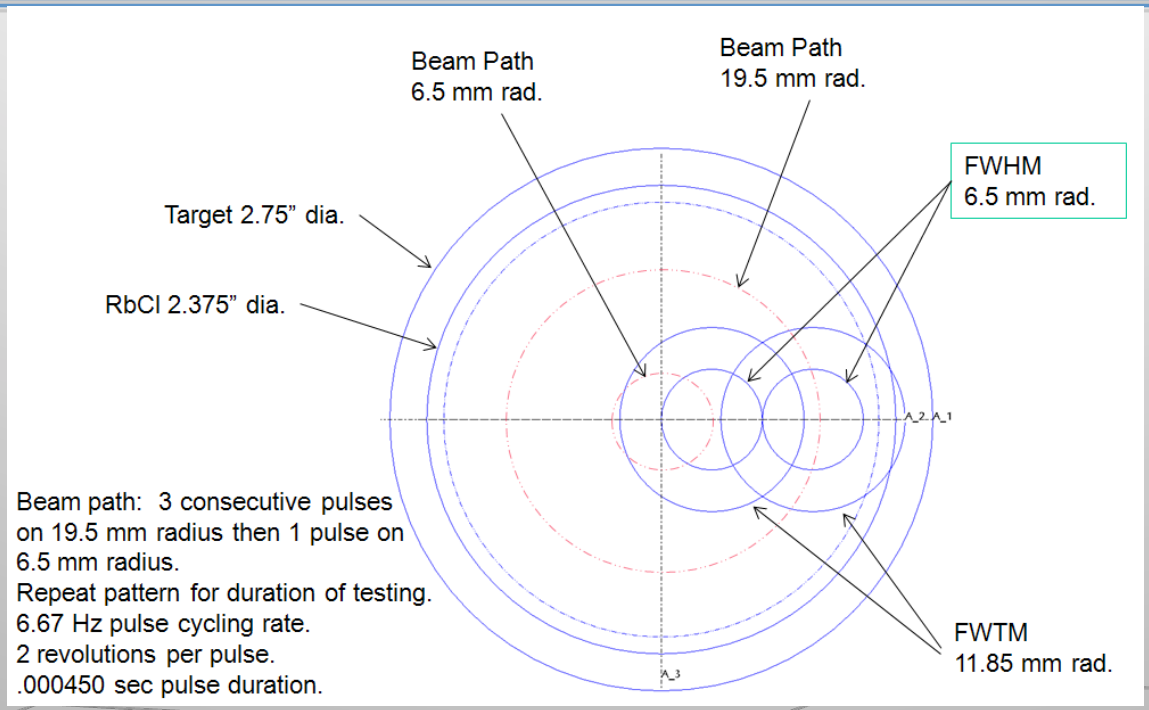


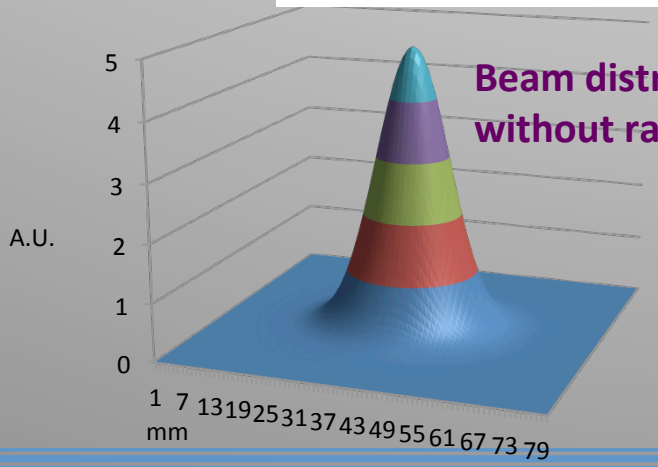
Project Mission/Purpose

- The purpose of the BLIP raster system is to “paint” the beam in a circular fashion to provide an even distribution of beam on the BLIP target by spreading out the power density.

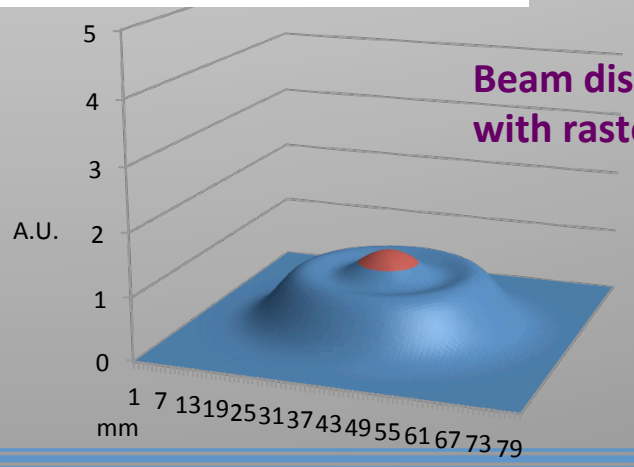
- As part of the project, several new instrumentation devices will be installed in the BLIP beam line.

Raster motion and distribution on target





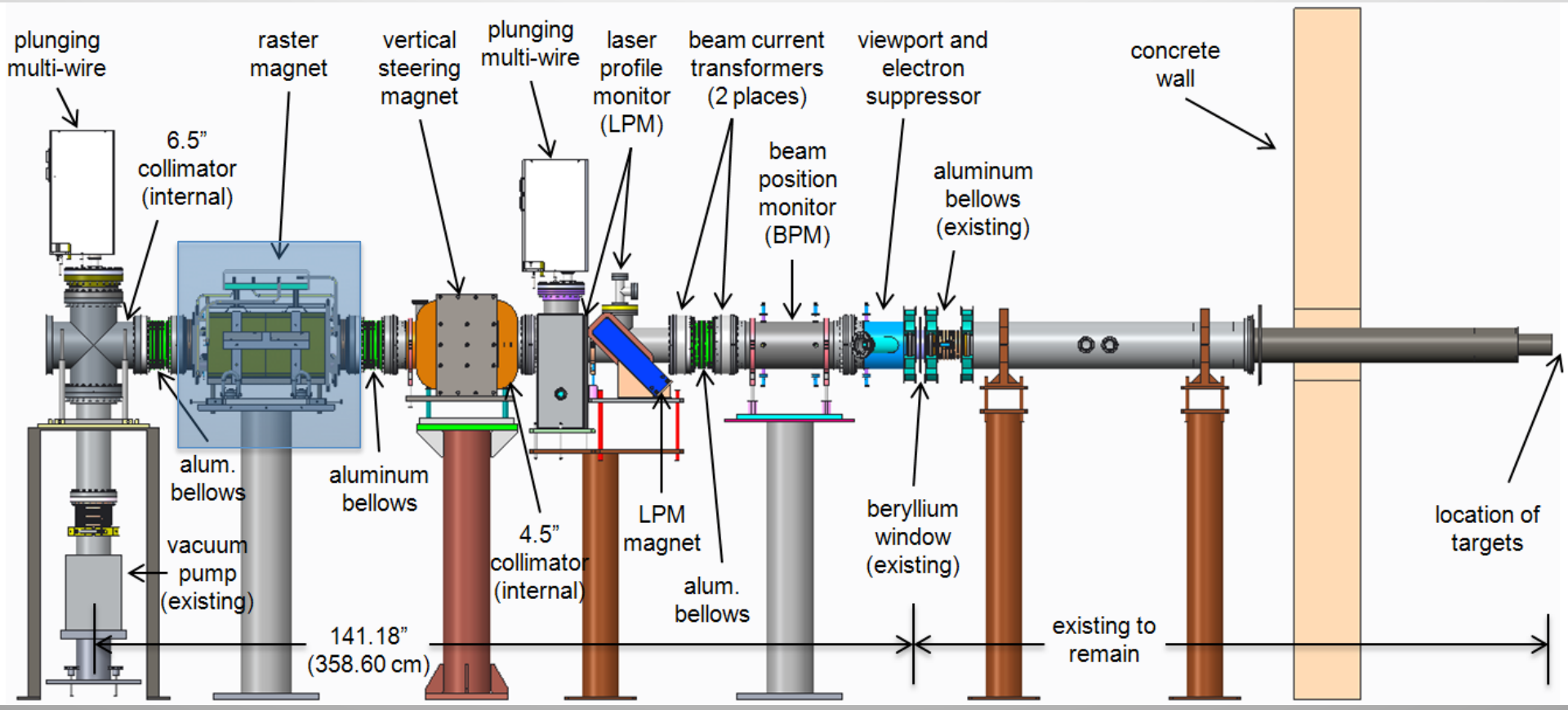
Beam distribution without raster



Beam distribution with raster

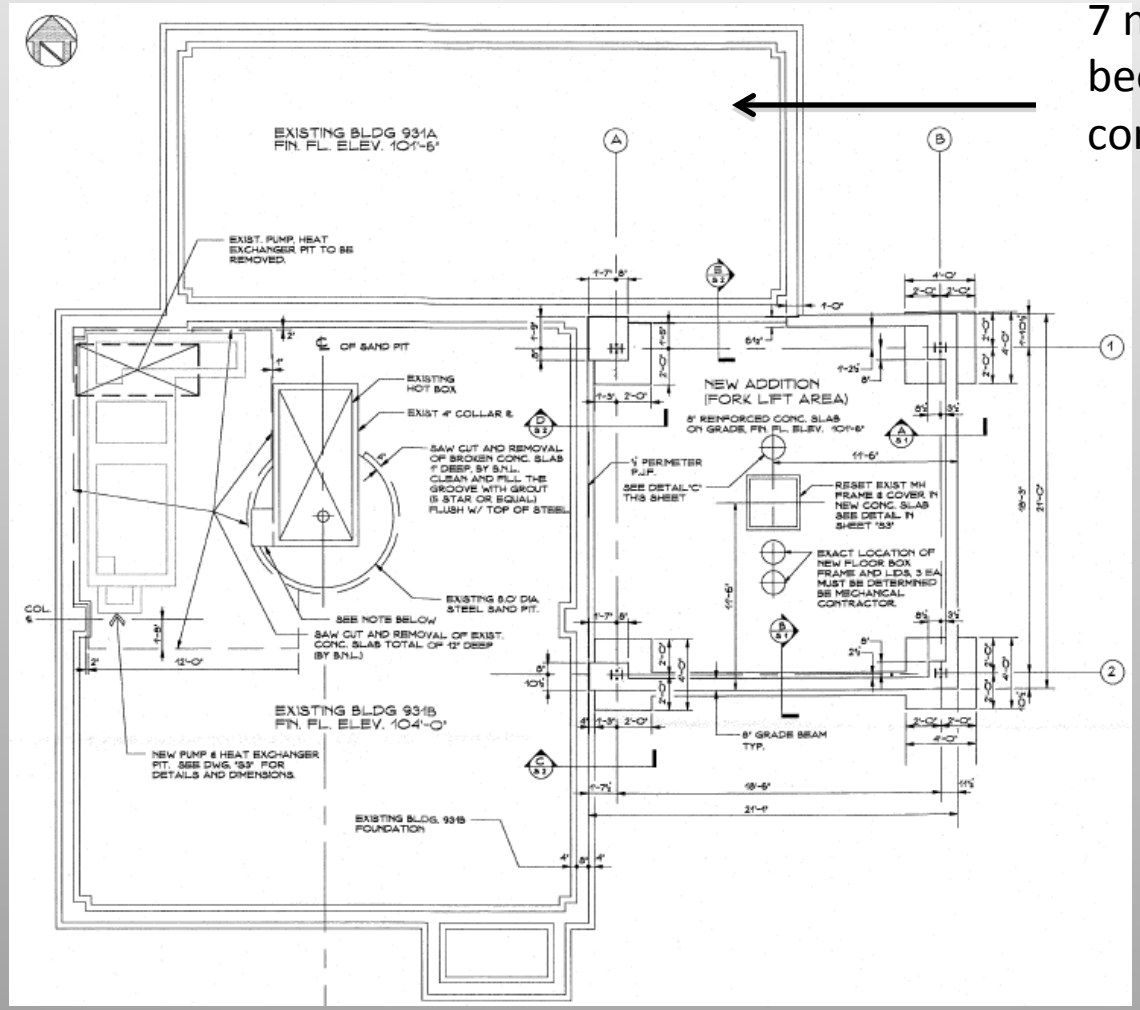
Integral of beam distribution is the same for both plots

New beam-line layout
All components except raster magnet were installed Oct. 2014



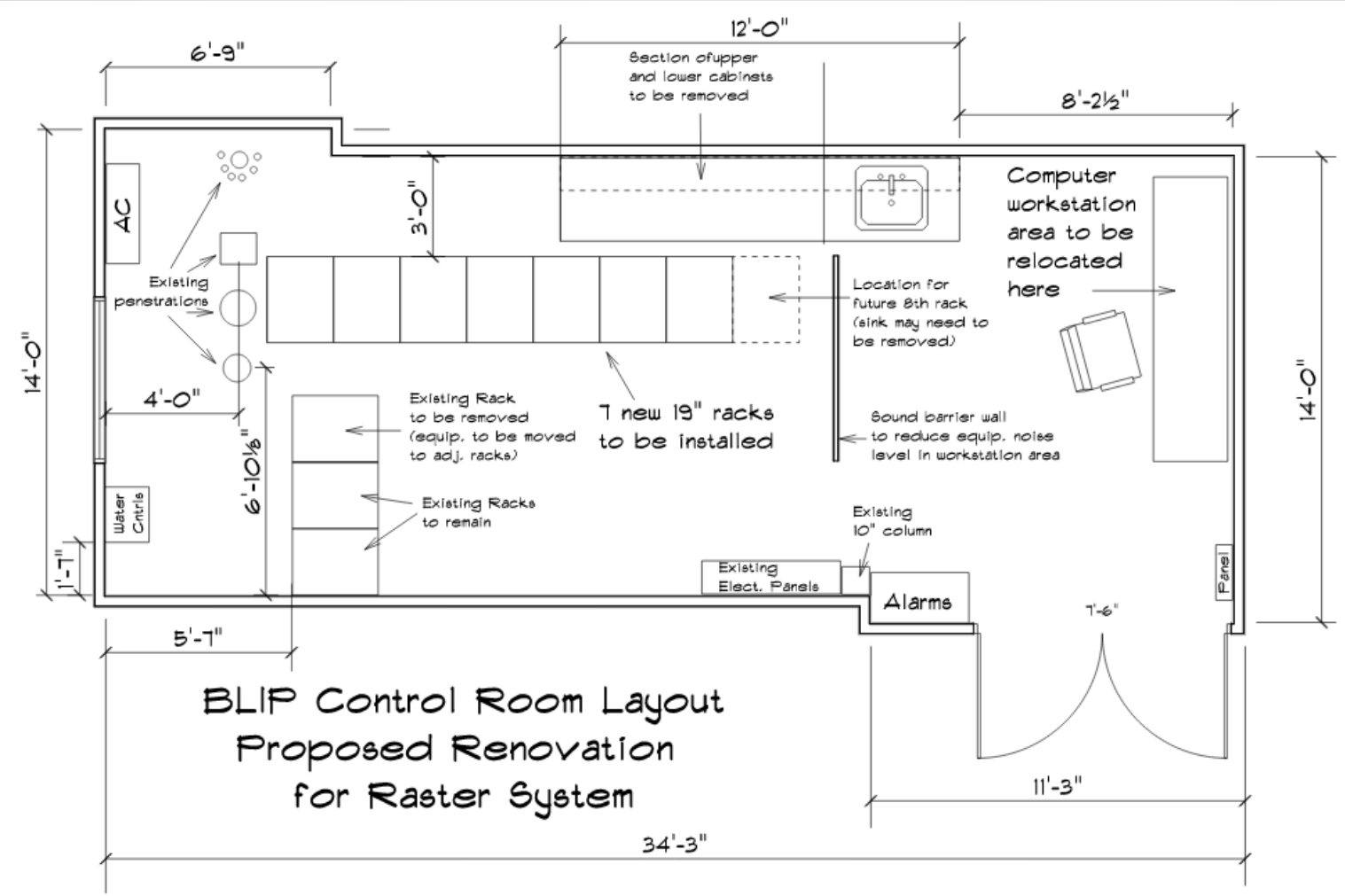
Project scope: Design, fabricate, install and commission a BLIP Raster system containing the components shown in the beam-line layout, and including all required mechanical, electrical and software systems.

BLIP Building Floor Plan



7 new equipment racks have been installed in existing BLIP control room

BLIP Building Floor Plan



Notes:

1. Ceiling area directly over new rack needs to be raised to provide space for cable trays.
2. Lighting in area over new racks must be relocated (2'x4' light fixtures could be rotated 90 deg such that they are not directly over the new cabinets).

Key Performance Parameters (KPPs)

- The Key Performance Parameters (KPPs) that define successful completion of the project are:
  - The raster magnets, power supply and associated beam-line vacuum components and electronic equipment are installed. This includes components in the tunnel as well as in the BLIP control room.
  - **The beam is modulated horizontally and vertically to produce 5 kHz circular rastering** of the beam with a fixed radius on the BLIP target.
  - The beam intensity is limited to 125 microAmps, the intensity that is currently used for non-rastered operation in order to provide additional safety against target damage.

Ultimate Performance Parameters (UPPs)

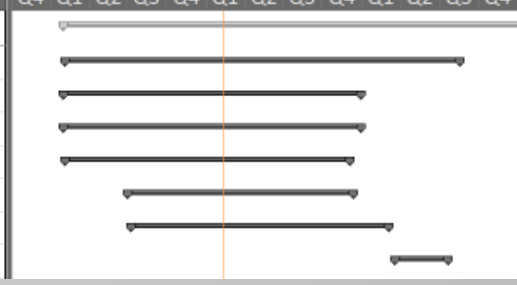
- **The circular rastering of the beam is configurable to occur at 2 different radii.** The anticipated operation is to raster the beam at a radius of 19.5 mm for 3 consecutive 450 microsecond long pulses (2.25 rotations per pulse), then raster the beam at a radius of 6.5 mm for one pulse, and repeat the pattern.
- The **beam interlock system** allows an average beam current of 140 microAmps.

ESSH&QA

- NEPA review raised two issues:
  - Soil activation at the BLIP tunnel
    - C-AD will extend a cap to shield the ground from rain to prevent a downward movement into the groundwater.
  - Increased isotope production will cause increased waste.
    - Waste will be stored by C-AD for a year to allow for significant decay before it is transferred to Waste Management.
- Per DOE BLIP Raster review request:
  - Exceeding present day Oxygen-15 emissions is not desirable.
  - Therefore the water gaps for BLIP target arrays cannot be increased without Radiation Safety Committee review.
  - OPMs are in place to control and manage the water gaps.
- The BLIP tunnel is a very high radiation & contamination area
  - Significant work planning is required to limit worker hazards

High Level Schedule

	WBS	Task Name	% Comple	Start	Finish
0	1.	Raster AIP	71%	Fri 11/1/13	Fri 12/2/16
1	1.1	Management	38%	Mon 11/4/13	Wed 5/18/16
14	1.2	Construction	79%	Fri 11/1/13	Mon 9/28/15
15	1.2.1	BLIP Raster System Instrumentation Upstream of Target	72%	Fri 11/1/13	Mon 9/28/15
101	1.2.2	Magnet and Vacuum Construction	88%	Mon 11/4/13	Wed 9/2/15
222	1.2.3	Power Supply Scanning System	68%	Tue 4/1/14	Thu 9/10/15
262	1.3	Installation	68%	Tue 4/8/14	Thu 12/3/15
346	1.4	Commissioning	0%	Fri 12/18/15	Thu 4/21/16



Notes:
Reported % complete assumes that components installed during this shutdown are fully successful. If significant problems are found during the commissioning effort (such as unanticipated radiation damage or devices not operating as expected), then additional costs will be incurred.

Project is on schedule

Financials as of October 2014

Raster AIP			FY15							
WBS	Title	FY14 Actuals	October Actuals	FY15 Actuals	Project to date (PTD) costs*	Burdened Commit-ments	Cost & commit-ments		Budget at Comple-tion		Budget less actuals / commts
1.1	Management	56.2	18.8	18.8	75.1	0.0	75.1		266		191
1.2	Construction	1490.6	300.9	300.9	1791.5	135.3	1926.8		2888		961
1.2.1	Instrumentation	825.5	167.8	167.8	993.3	1.5	994.8		1932		937
1.2.2	Magnet and Vacuum	458.8	42.3	42.3	501.1	130.3	631.4		646		14
1.2.3	Power Supplies	206.3	90.8	90.8	297.1	3.5	300.6		311		10
1.3	Installation	99.1	11.5	11.5	110.6	0.0	110.6		511		400
1.4	Commissioning	0.0		0.0	0.0	0.0	0.0		82		82
	Contingency	0.0		0.0	0.0	0.0	0.0		753		0
	Total (Actual Cost of Work Performed)	1645.91	331.3	331.3	1977.2	135.3	2112.5		4500		1634
	Budgeted Cost of Work Planned						2320.0				
	Cost Performance Index						1.1				

All values are in $k and include labor and materials

Isotope Funding from ONP
FY14 - $3.6M
FY15 - $0.9M

Contingency: 20% of baseline cost
Expenditures to date: 56% (excluding contingency)

Expenditures to date are within the project plan
Contingency spent to date: $0

Schedule Performance – Project Milestones

Reporting Milestones	date	actual date
Project Start	Nov 4 2013 (A)	Nov 4 2013 (A)
Designers assigned to project	1QFY14 (A)	1QFY14 (A)
Access BLIP Spur	1QFY14 (A)	1QFY14 (A)
PM trip to LANL	2QFY14	
Current Transformers ordered	2QFY14 (A)	2QFY14 (A)
Material ordered for Plunging Multiwire Profile monitor	2QFY14 (A)	2QFY14 (A)
Decision on Rad Hard vs. periodic replacement	3QFY14(A)	3QFY14 (A)
Design Review & Accelerator Systems Safety Review	4QFY14	3QFY14(A) / 4QFY14(F)
Summer/Fall 2014 access to BLIP Tunnel	1QFY15	1QFY15(A)
All power supply purchases received	2QFY15	4QFY14 (A)
Vacuum fabrication begins	3QFY15	4QFY14 (A)
Magnet stand fabrication begins	3QFY15	
Vacuum Chamber bakeout	4QFY15	
Summer/Fall 2015 access for BLIP Tunnel Installation	4QFY15	
Raster magnet available for installation	1QFY16	
Plunging Multiwire Profile Monitor available for installation	1QFY16	
Accelerator Systems Safety Review-installed	1QFY16	
Power supply installation	2QFY16	
DOE approval to operate	2QFY16	
Begin Raster System test without beam	3QFY16	
Confirmation of Rastering	4QFY16	
Project complete	1QFY17	

Major milestones have been achieved according to the plan

Risk Register (partial)

WBS	Risk	Mitigation Plan	Owner	$
1.0	High Radiation Area	Consider rad-hard designs, locating equipment outside tunnel, Careful work planning	Raster team	50k
1.2.1	Signal integrity suffers for equipment not located in tunnel	Contingency is included to consider integrity issues and weigh radiation damage vs. low level signals/long cables.	Raster team	
1.0	Availability of penetrations and adequate shielding between tunnel and BLIP control rm.	Contingency included to provide additional penetrations and adequate radiation shielding.	Pontieri	$100k
1.0	Availability of personnel & resources	Use of overtime, contract labor	Michnoff	

Potential Hazards

- Major potential hazards have been identified, and plans for controlling each hazard have been addressed

Major Potential System Hazards

System	Component	Potential hazards	Plan for controlling hazard	Notes
Laser Profile Monitor (LPM)	Laser	Standard laser hazards	Laser will be interlocked with access control system, guaranteeing that personnel will not be present in the tunnel when the laser is active. Laser head located in the control room will be installed in dedicated box to prevent tampering and inadvertent disconnecting of fiber optic cable.	Laser head is located in the control room, laser light is transmitted to the optics box in the beam tunnel via fiber optic cable.
	Detector magnet	Overheating	Klixon temperature switches will be installed on magnet, and programmable logic controller (PLC) will turn off the magnet power supply if the magnet temperature limit is exceeded.	
	Sorenson power supply for detector magnet	Over-voltage, over-current could cause equipment damage	The power supply has built-in over-voltage and over-current protection.	Sorenson power supply model DCS-20-60 Input: 120VAC,20A, 60Hz Output: 0-20VDC, 0-60Amps
	Bias power supply for faraday cup	No unusual hazard	Standard electrical safety rules, procedures and practices apply.	Max output: 48VDC, 0.57Amps
General control and instrumentation electronics		No unusual hazards	Standard electrical safety rules, procedures and practices apply.	

Major Potential System Hazards

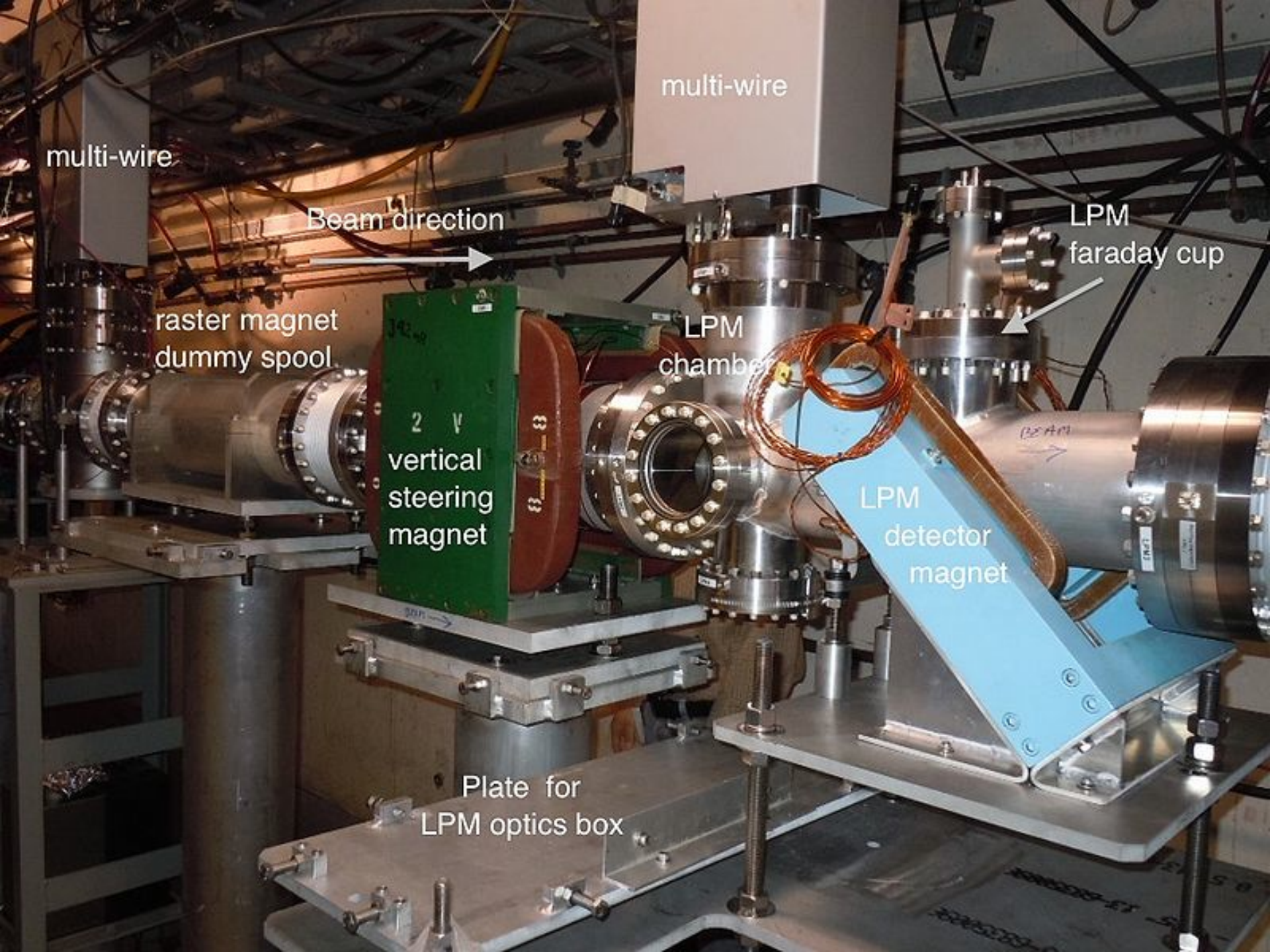
System	Component	Potential hazards	Plan for controlling hazard	Notes
Raster magnet power supply	Output power	High power output presents personnel safety hazard	Litz wire cable from control room rack to raster magnet in tunnel will be installed in conduit and satisfy fire code. (specific details to be determimined) LOTO procedure will be used to prevent personnel from being near magnet conductors during power supply operation. Access through gate to BLIP spur will require that the power supplies are LOTO'd. Racks in control room will be locked when power supplies are enabled for operation.	Output power: 105 KVA apparent power 225 Amps RMS (318A peak) 470 Volts RMS (664 V peak)
	Raster magnet	Overheating	Klixon temperature switches will be installed on magnet, and power supply control system will turn off the magnet power supply if the magnet temperature limit is exceeded.	
Target protection			A beam interlock system will be installed to disable beam from LINAC to the BLIP beam-line when rastering is not occurring as expected. The main purpose of this system is to prevent BLIP target failure. Some redundant hardware will be provided to improve system reliability.	2 methods of interlocking beam will be provided: 1. Disable chopper (existing) 2. Disable 35 keV LEBT pulsed dipole magnet

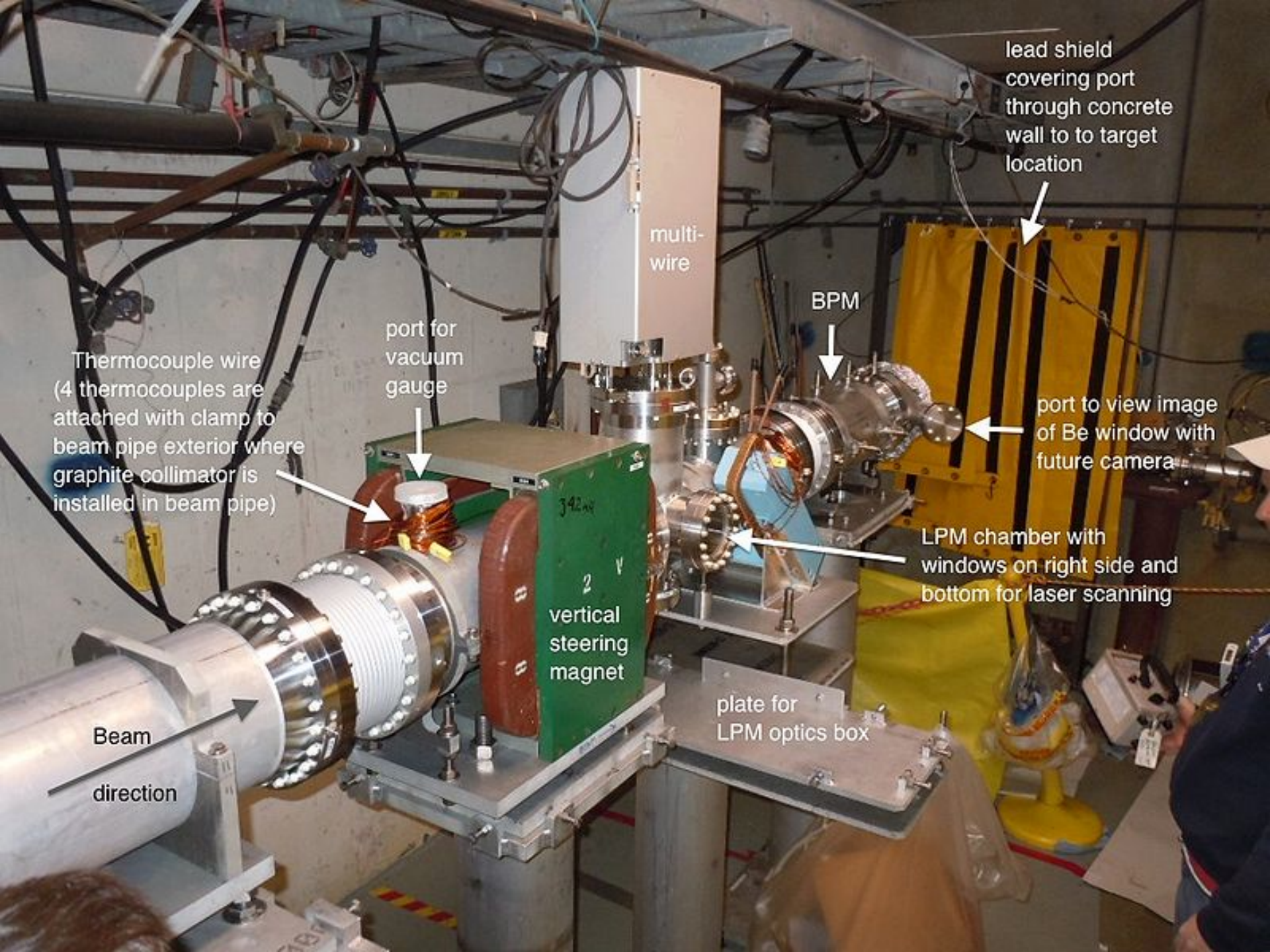
Major Potential Radiation Hazards

Hazard	Concern	Plan for controlling hazard	Notes
High radiation levels in BLIP tunnel	Worker exposure during installation of systems in tunnel	Extensive work planning will be provided to ensure that dose to workers is minimized.	
Penetrations from control room to tunnel for equipment cabling	Elevated radiation levels into control room	Shielding of penetrations at control room floor will be provided to limit residual radiation into the control room.	
Survivability of equipment in tunnel	Damage to equipment in tunnel due to high radiation levels	Radiation hardened equipment will be designed where feasible, some equipment will be periodically replaced since radiation damage is expected (for example, cable sections from beam-line to cable tray)	

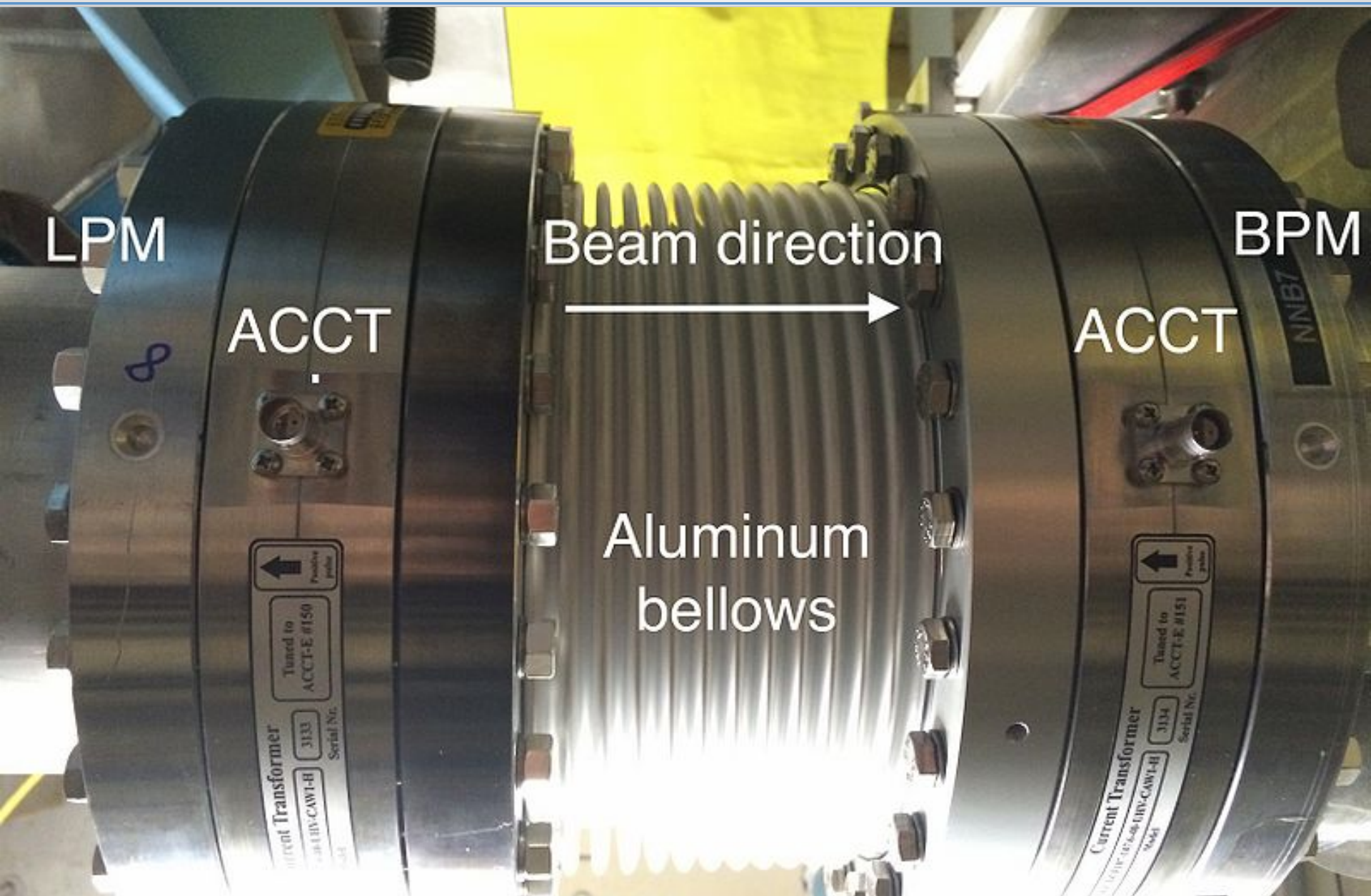
Status and near-term Plan

- Completed installation of new beam-line section (excluding raster magnet) last week of October 2014. This includes all vacuum and instrumentation devices.
- Equipment racks are installed. Rack wiring has begun.
- Cable pulling from tunnel to control room is complete.
- System installation will be complete in time for December 7th FY15 first beam. Instrumentation will be commissioned during FY15 beam run.
- Software/firmware development will be ongoing during the FY15 beam run.

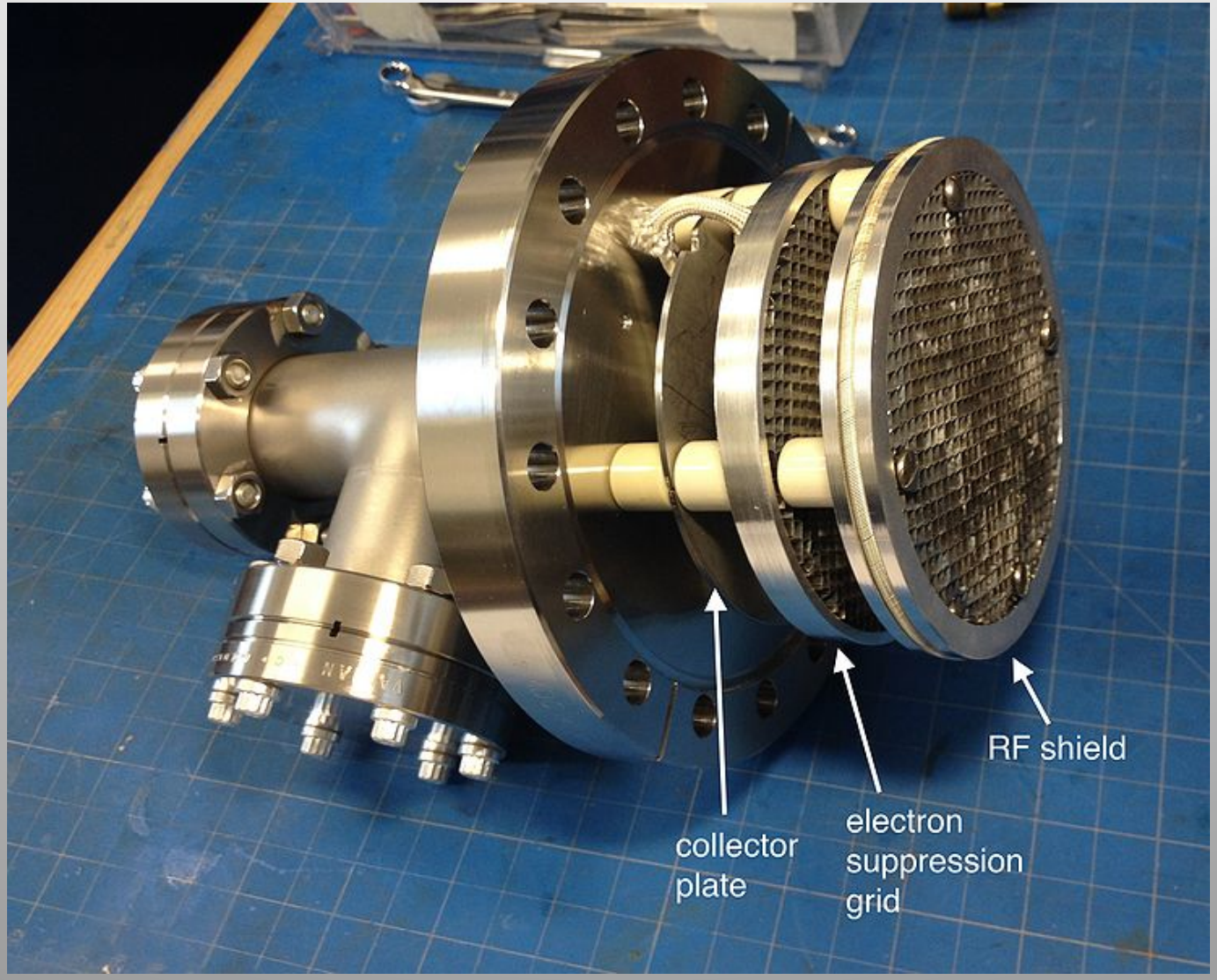

multi-wire
multi-wire
Beam direction
LPM
faraday cup
raster magnet
dummy spool
LPM
chamber
2 V
vertical
steering
magnet
LPM
detector
magnet
Plate for
LPM optics box


lead shield covering port through concrete wall to to target location
multi-wire
BPM
port for vacuum gauge
Thermocouple wire (4 thermocouples are attached with clamp to beam pipe exterior where graphite collimator is installed in beam pipe)
port to view image of Be window with future camera
LPM chamber with windows on right side and bottom for laser scanning
vertical steering magnet
plate for LPM optics box
Beam direction

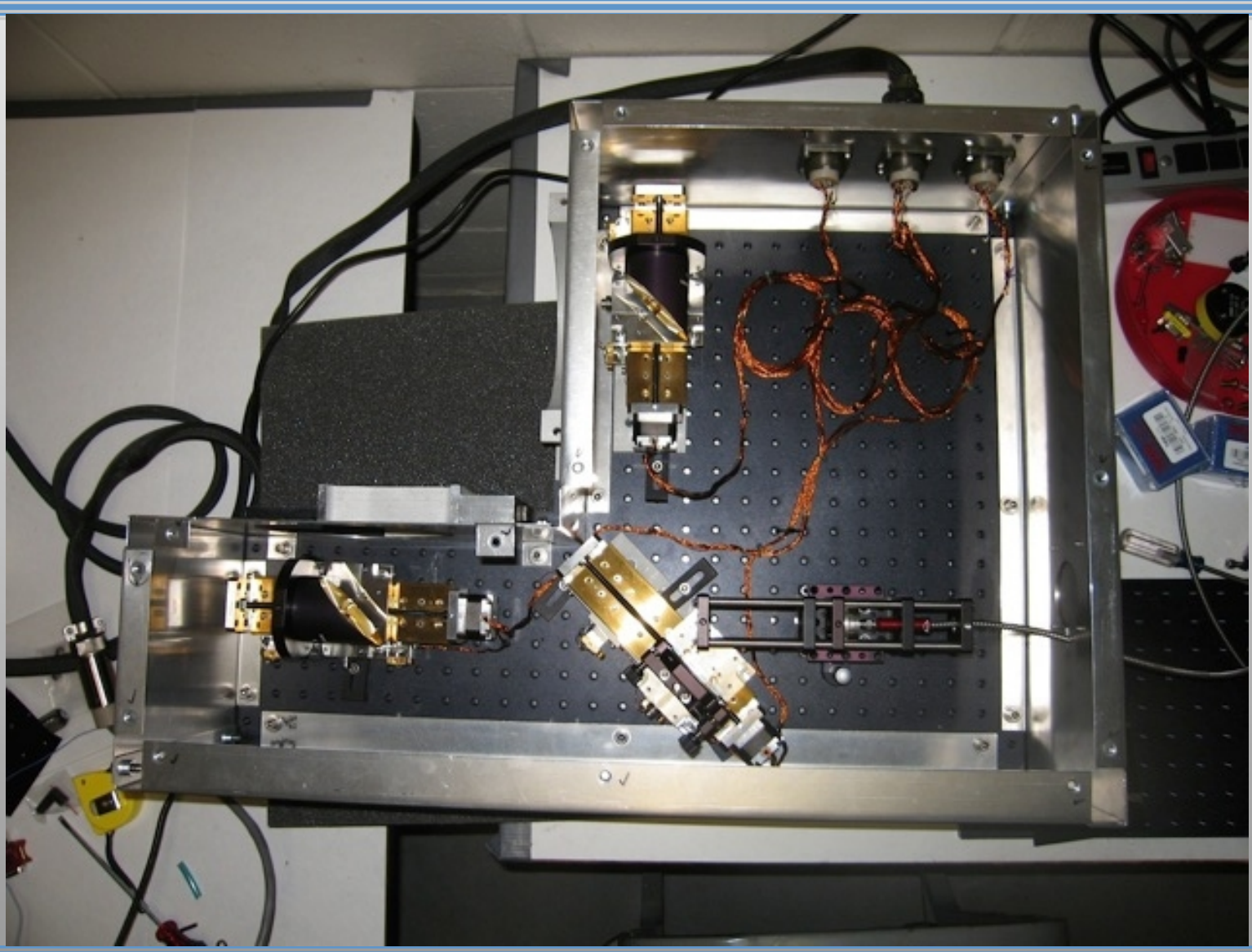
Beam current transformers



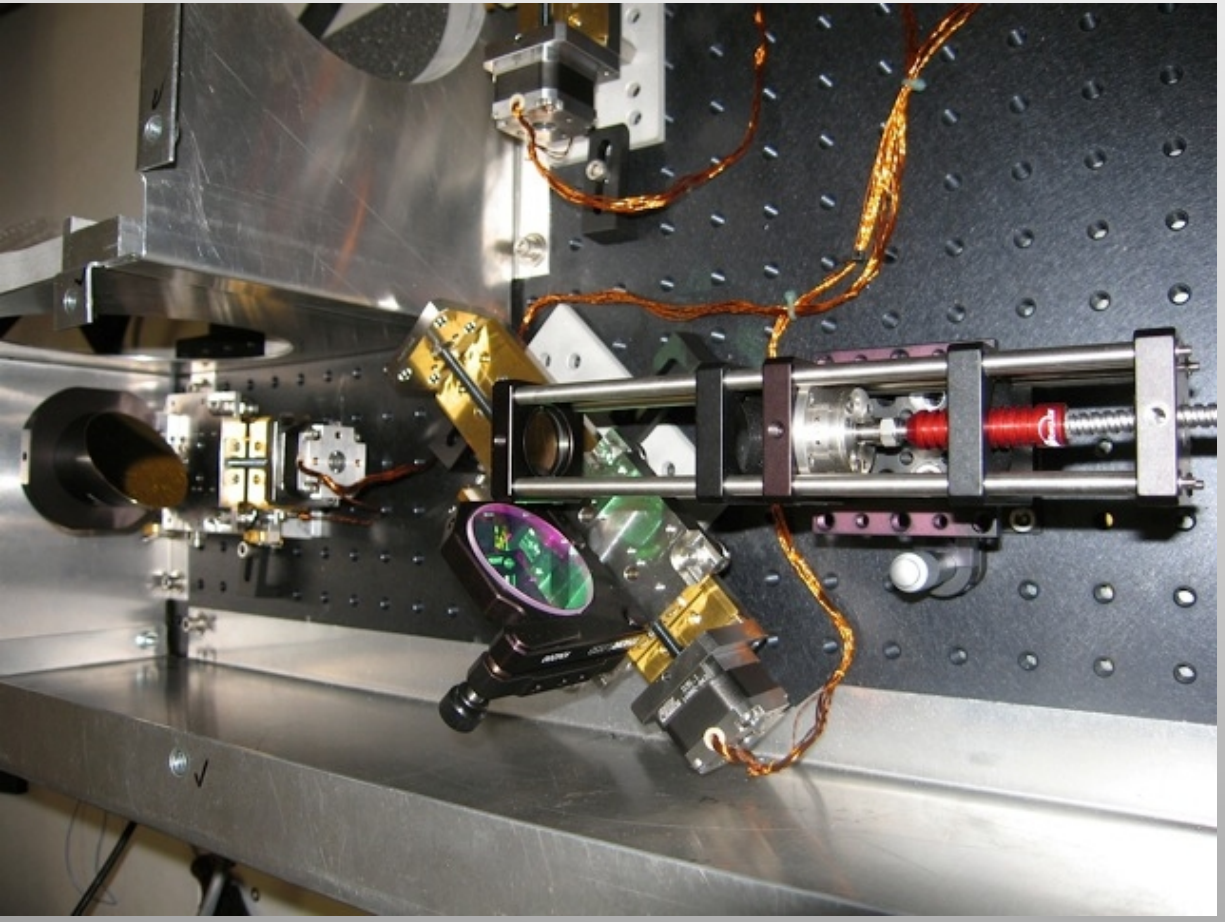
LPM Faraday Cup



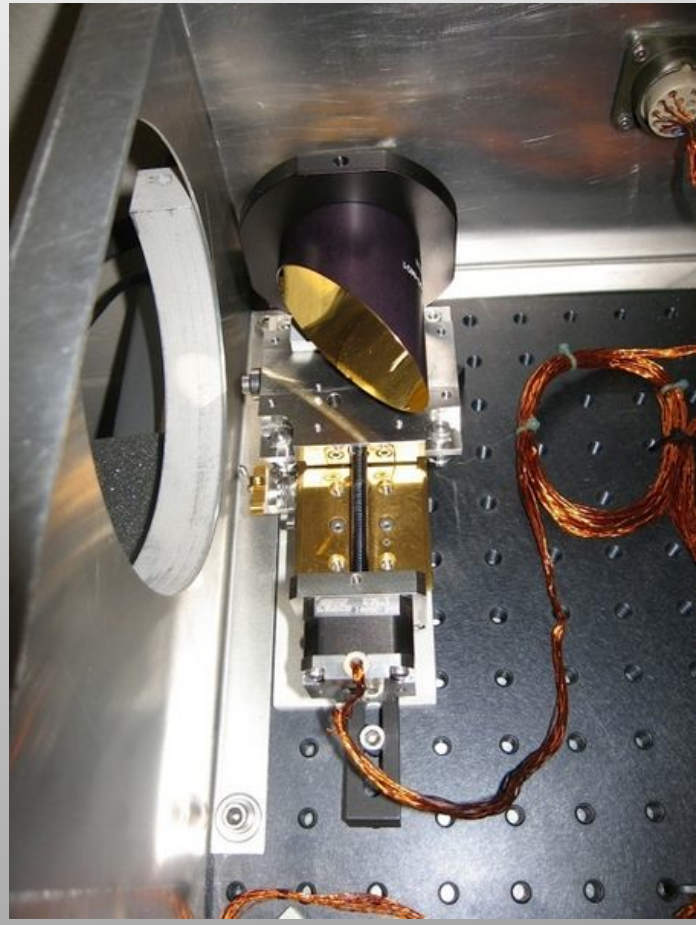
LPM Optics Enclosure



LPM Optics Enclosure

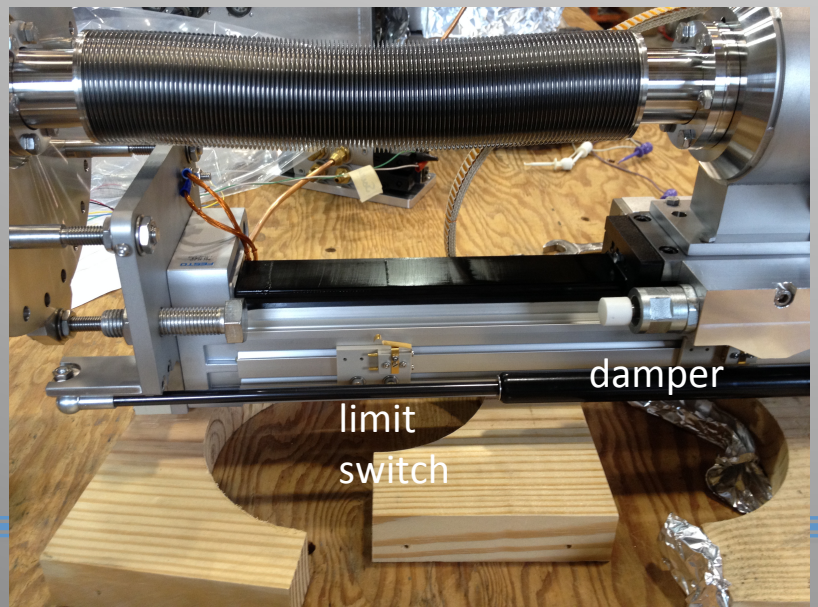


Horizontal scanning mirror on left, 45 deg mirror selects between horizontal or vertical and is shown here in the position for horizontal scanning.

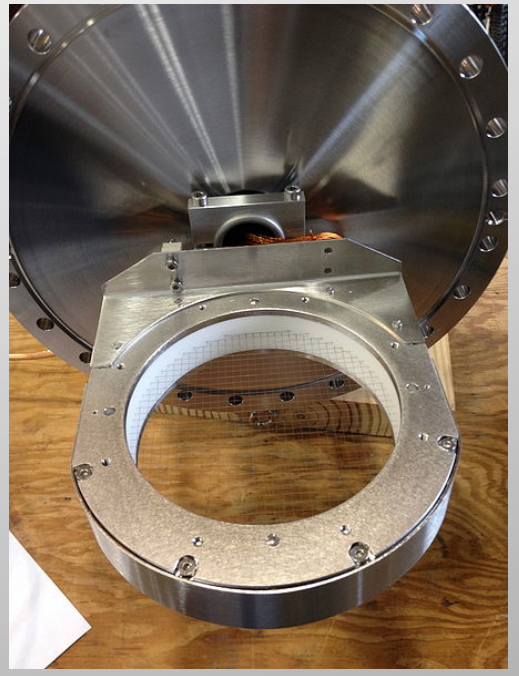


Vertical scanning mirror.

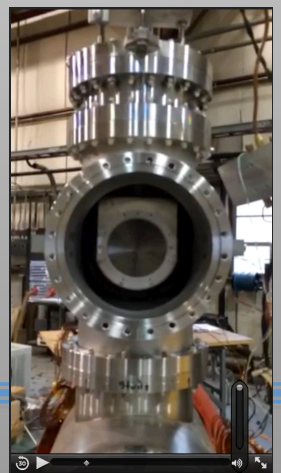
Multi-wire



Multi-wire inserted in LPM chamber

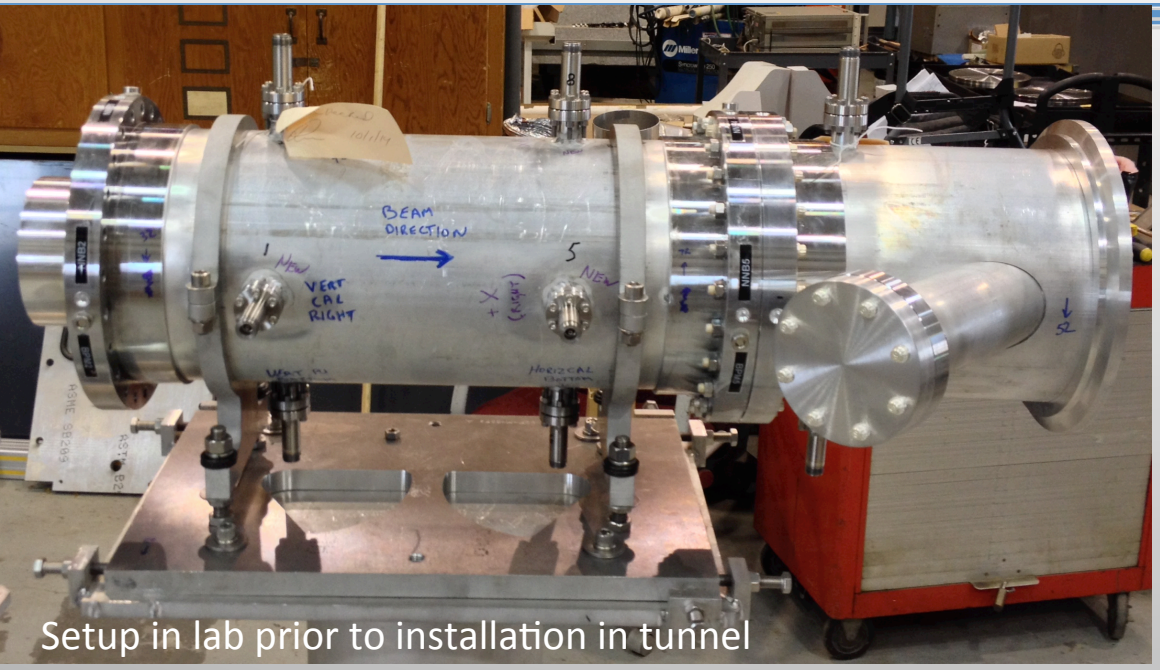


32-wire X 32-wire grid assembly

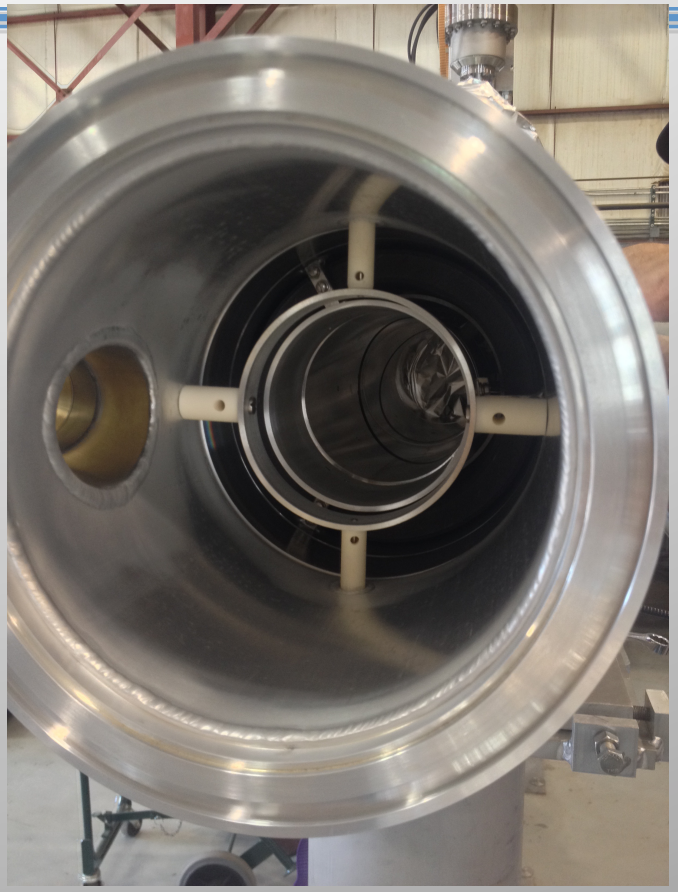


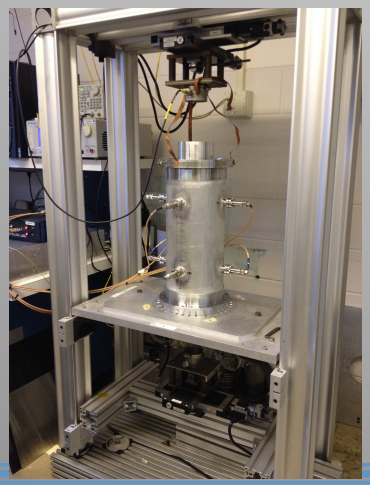
movie of multi-wire plunging into vacuum cross section

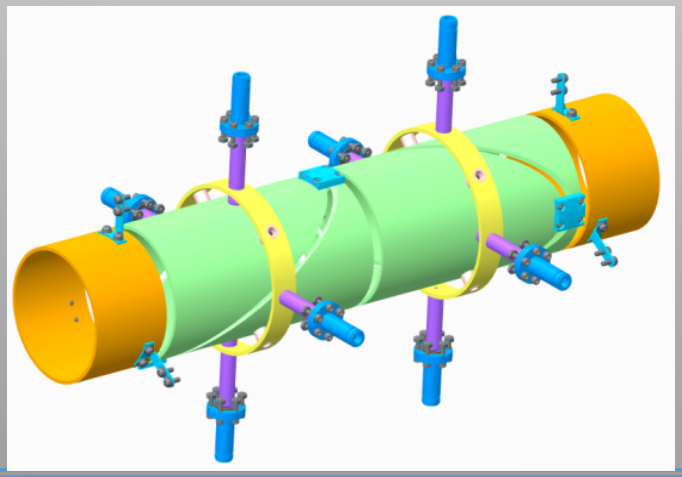
BPM and viewport



Setup in lab prior to installation in tunnel


Viewport section, looking in direction opposite of beam. Viewport for future camera is on left side. The first ring with alumina standoffs is electron suppression ring. The BPM extension section and pickups are visible further into the beam pipe.

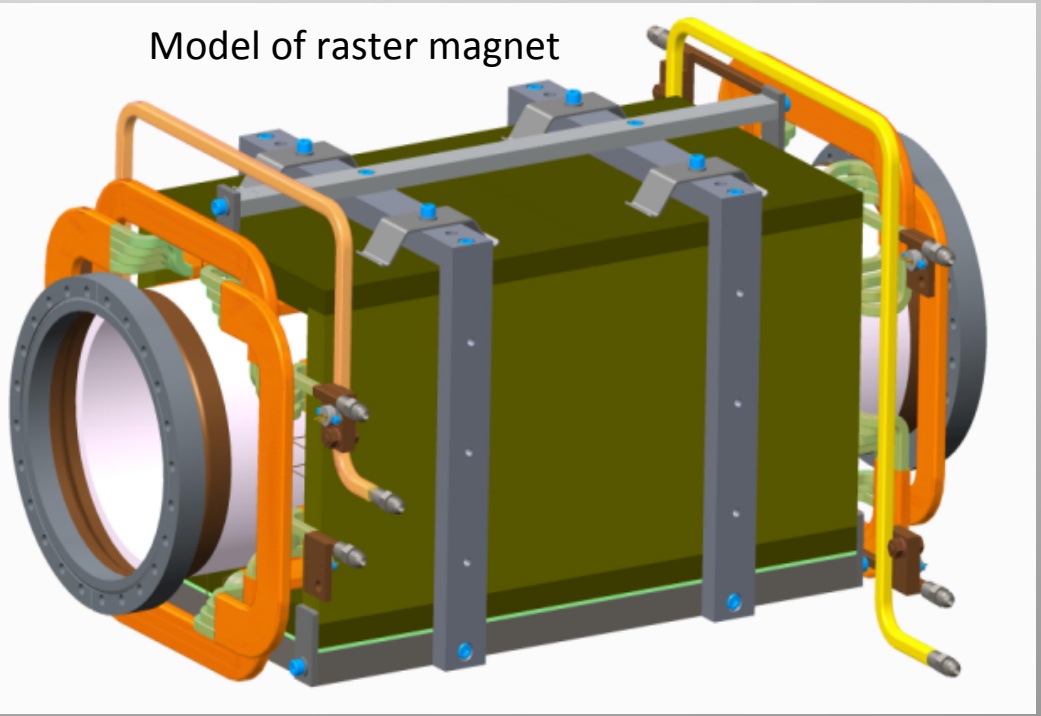

BPM wire scanner


Model of BPM internal components

BLIP Control Room Equipment Racks (11/7/2014)

Plan for Raster Magnet Fabrication and Testing

- Raster magnet ceramic spool piece has been procured, delivery is expected to be received late December 2014. This section will then be sent out to another vendor for coating. Expect coated ceramic spool section to be received early February 2015.
- Magnet coils have been procured. Delivery is expected late January 2015.
- Magnet ferrites have been procured. Delivery is expected mid February 2015.
- Magnet assembly will be performed on-site February-March 2015.
- Power supply testing with magnet to begin after magnet assembly is complete, April 2015.
- Magnet and power supply to be installed October 2015.



Short-term to-do list

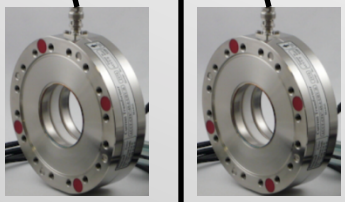
- Complete interconnecting wiring
- Complete construction of cable penetration radiation shielding
- ASSRC walkthrough (Accelerator Safety Systems Review Committee)
- Final survey of beam pipe assembly in tunnel
- Integration testing prior to beam

Short-term to-do list

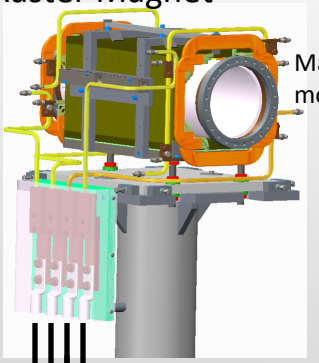
- Develop instrumentation commissioning plan.
- Review risk register and retire or add items as needed.
- Review work remaining to ensure that estimated cost to complete is aligned with remaining funding.
- Work with ONP to determine viability of adding scope with unused contingency
  - Determine if funding is available for new style Beryllium window (to allow visibility through viewport)
  - Determine if funding is available to design and purchase camera system for viewport
- Estimate and purchase spare equipment
- Magnet assembly
- Power supply testing

BLIP Beam Interlock System Block Diagram

Current Transformers

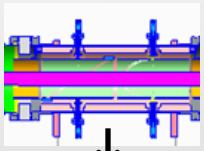


Raster Magnet

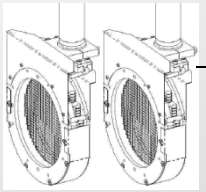


Magnetic Field monitor coils (4)

Beam Position Monitor



Harps



Limit switches

Relays

Not mid-travel

BPM Module

BPM Raster OK

Power Supplies OK

Beam Current OK

Beam Current OK (2)

PS Raster OK (2)

Mag. Field Raster OK (2)

V120 Permit Module

Permit inputs

Permit out

FEC

To Existing Linac Fast Beam Inhibit System

output

output

Raster Magnet Power Supply (vertical)

Raster Magnet Power Supply (horizontal)

PXIe/Labview Power Supply Controller (resonance & phase control loops)

Integration/Hi current interlock

+/-10V

Bergoz ACCT electronics box

Existing BLIP Control System

New collimator hi temp

Existing collimator hi temp, loss monitors

3 outputs per zynq board

Xilinx ZC702 Zynq board (2 redundant units, all I/O duplicated)

Digital Outputs

Horiz magnetic field

Vert magnetic field

Horiz PS current

Horiz PS voltage

Vert PS current

Vert PS voltage

Beam current

4DSP FMC112 12-chan, 14-bit, 125MSPS ADC board

Bergoz ACCT electronics box

+/-5V

Divider/Driver

+/-1V

BLIP Raster Project Team

- Leonard Mausner – Radioisotope Research Head
- Rob Michnoff – Project Manager
- Kerry Mirabella, Bob VanWormer – Project Controls
- Ed Lessard, Asher Etkin – Safety and QA Manager
- Deepak Raparia – Accelerator Physicist; LINAC
- Chris Cullen – Mechanical Engineer; everything mechanical
- Bob Lambiase – Electrical Engineer; Raster power supply
- Roger Connolly – Instrumentation Physicist; LPM and more
- Peter Thieberger – Instrumentation Physicist; BPM simulations & modeling
- Rob Hulsart – Digital Engineer; BPM and more
- Steve Pontieri – Facilities Engineering
- Zeynep Altinbas – Power Supply Controls
- Chung Ho – Electrical Engineer; BLIP PLC
- Craig Dawson – Electrical Engineer; ACCT divider/driver circuit
- Winston Pekrul – Digital Engineer; beam interlock
- Phil Cernigla, Tony Curcio, Dan Lehn – Technical coordination
- Chris Degen, LPM, Current Transformers
- Lenny DeSanto – LPM engineering consulting
- Many others – BLIP personnel, controls engineers, radiological control division personnel, mechanical technicians, electronic technicians, vacuum technicians, electricians, surveyors, cable pullers, riggers, central shops personnel, outside vendors

Summary

- Project costs and schedule are on track with the plan
- All defined performance parameters are expected to be achievable
  - Significant work is still required and several challenges still exist.
- We had a very aggressive internal goal to install all instrumentation for the 2015 beam run… and we succeeded.
  - This will provide ample time to commission the instrumentation prior to installation of the raster magnet and power supply next year.
- Raster magnet and power supply will be installed next year around this time.
- Full system commissioning with raster is expected to begin as soon as first beam is available in FY16 run.